

IMPLEMENTATION PLAN:
SUMMER 2006 SAMPLING EVENT
WESTSIDE TYPE N RIPARIAN BUFFER CHARACTERISTICS,
INTEGRITY AND FUNCTION STUDY

Prepared for the Riparian Scientific Advisory Committee

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BACKGROUND

The west side Type N Buffer Characteristics, Integrity and Function Study was initiated in 2003. The purpose of the study is to evaluate the effectiveness of the westside Type N riparian prescriptions by documenting changes in stand characteristics, tree mortality and riparian functions at a set of randomly selected sites where the westside Type N riparian prescriptions were applied with unharvested reference sites.

Current Status

This section describes the current status of the effort to implement the Type N BCIF study plan (Schuett-Hames et al., 2003).

Site selection

Site selection for the project was completed in 2003. There are 15 treatment sites randomly selected from approved Forest Practice Applications for Type N harvest in the western hemlock zone of western Washington. Each treatment site contains a Type 4 (Np) stream harvested in the summer-fall of 2003 using the west side Type N prescriptions. Some parts of the treatment streams received 50 ft no-cut buffers, others were clear cut to the stream, and perennial initiation points (PIPs) were buffered. Each treatment site was paired with an unharvested reference sites.

Data collection

The study plan called for sampling events the first year after harvest and at intervals of 3 and 5 years following harvest. The initial post-harvest sampling effort was designed to test the efficacy of different sampling methods. In the first year, data were collected on riparian stand characteristics, under-story vegetation, tree mortality, LWD recruitment, shade, soil disturbance and channel characteristics.

Purpose of the Document

The purpose of this document is to describe the 3rd year data collection and analysis effort planned for the summer-fall of 2006. The remainder of the document is divided into three sections based on study objectives; 1) stand development, tree mortality and woody debris recruitment, 2) soil and channel disturbance, and 3) shade. In each of the three sections information is presented describing the objectives, the methods and procedures used in 2003-4, the methods proposed for 2006. A fourth section describes new study objectives that were identified following analysis of the first two years data.

STAND DEVELOPMENT, TREE MORTALITY AND WOODY DEBRIS RECRUITMENT

Objectives

Stand development

This component addresses the high level of uncertainty concerning riparian stand growth and development trajectory following application of the FFR Type Np riparian prescriptions.

1. Obtain an unbiased estimate of post-harvest stand characteristics in Type Np riparian buffers and monitor changes over time following application of the prescriptions.

2. Evaluate the duration and magnitude of post-harvest changes in stand attributes associated with the Type Np prescriptions relative to un-harvested reference sites.
3. Identify site and stand attributes that influence stand condition and trajectory.

Tree mortality

This component addresses uncertainty concerning the effect of FFR Type Np riparian prescriptions on woody debris recruitment to adjacent stream channels.

1. Obtain an unbiased estimate of post-harvest tree mortality in Type Np riparian buffers.
2. Evaluate the magnitude and duration of post-harvest tree mortality in Type N riparian buffers relative to un-harvested reference sites.
3. Identify site or tree attributes that influence tree mortality rates in Type N buffers.
4. Estimate the effect of buffer tree mortality rates on stand condition, trajectory, shade, and woody debris recruitment.

Woody debris recruitment

This component of the study addresses uncertainty concerning the survival of leave trees in FFR Type Np riparian buffers.

1. Obtain an unbiased estimate of post-harvest woody debris recruitment rates for Type Np riparian buffers and monitor changes in those attributes over time following application of the prescriptions.
2. Evaluate the duration and magnitude of post-harvest changes in woody debris recruitment potential and rates at treatment sites relative to untreated reference sites.
3. Identify site and stand attributes that influence woody debris recruitment.

Review of 2004 data/methods

Two approaches for acquiring data on riparian stands, tree mortality and LWD recruitment were tested, a field and a remote sensing method. The field method (Roorbach and Schuett-Hames, 2005) established two rectangular fixed-area plots at random locations in each reach. Plots measured 60 ft along the stream and extended out 50 ft on both sides of the stream for a total width of 100 ft. The remote sensing method involved interpretation of low altitude aerial photos taken with cameras mounted on a boom suspended from a helicopter. This technique produced high resolution stereo pairs at a scale of approximately 1:2,000 covering the entire site.

Both methods were problematic. Permanent plots were difficult to establish in steep terrain. However, the most serious drawback was in the lack of power to detect differences due to the small sample size (2 per patch) and variability in the treatment sites. Due to the variability, increasing the number of plots would not substantially improve the power to detect differences between sites. The remote sensing approach addresses variability by producing a census of the entire site. However, there were technical difficulties with the photo interpretation. In addition, the dense canopy of second growth stands limited the ability of interpreters to see the small Type N channels and accurately count trees, particularly fallen trees or standing trees below the overstory canopy. Because of these limitations, a field inventory method will be used to census trees, tree mortality and LWD recruitment in 2006.

Data were also collected on tree regeneration and under-story vegetation. The primary objectives in collecting under story data was to document tree regeneration (changes in the numbers, size, and species composition of seedlings and saplings) over time and to document

shrub response to the prescriptions. Data were collected at six 1/100th acre circular plots located on the central transect of the rectangular plots. These plots were located at 10, 25 and 40 ft from the edge of the bankfull channel on both sides of the stream. Tree seedlings and saplings were tallied by species in each regeneration plot. The dominant and subdominant shrub species and the mean height of the shrub overstory were recorded. The percent shrub/sapling/seedling cover and the percent cover of small woody debris in each regeneration plot were estimated.

2006 Data Collection Protocols

This section describes data collection and analysis proposed for stand development, tree mortality and LWD recruitment in the summer of 2006. For this sampling event, the emphasis will be on documenting tree mortality, fallen trees and LWD recruitment. We propose to change the system for collecting data on standing trees, tree mortality and LWD recruitment to a field inventory that provides a census of all standing and fallen trees within 50 ft of the stream for each patch surveyed. This method is similar to the approach used by the Eastside Type F BTO add-on and the Hardwood Conversion projects. The parameters that will be collected and used in the analysis of stand development, tree mortality and LWD recruitment are similar to 2004 with a few exceptions. No data will be collected on stumps during the 2006 field visits. Tree diameters will be estimated and recorded in 4 in diameter categories. Revised damage codes will be substituted for the tree crown codes used previously. The system for collecting understory vegetation data will remain the same as in 2004. A more detailed description of the field methods for collecting data are contained in Appendix A (standing trees and tree mortality), Appendix B (fallen trees and LWD recruitment) and Appendix C (understory vegetation and regeneration).

Live trees

Data are collected on all live trees ≥ 4 dbh within 50 ft of the bankfull channel. The inventory will produce a census of all trees in the RMZ on each site. The data collected includes:

1. cell ID number
2. species
3. breast height diameter class (in 4" increments)
4. canopy class
5. landform
6. damage code

Dead trees (snags)

Data are collected on all dead trees (snags) within 50 ft of the bankfull channel. The inventory will produce a census of all dead trees in the RMZ on each site. The data collected includes:

1. species (if discernible)
2. breast height diameter class
3. landform
4. snag height code
5. decay class
6. mortality timing
7. mortality agent

Fallen trees

Data are collected on all fallen trees which originate (were rooted) within 50 ft of the bankfull channel and which fell after the initiation date of the study (summer 2003). The inventory will produce a census of all fallen trees on the site (by patch type) originating in the RMZ. Fallen

trees will be tagged and marked with paint to distinguish newly fallen trees on subsequent surveys. Data collected from each fallen tree includes:

1. tag number
2. condition (live/dead)
3. species
4. breast height diameter
5. type (uprooted, broken)
6. number of pieces (if broken)
7. number of pieces recruited
8. process
9. decay class
10. landform
11. total length
12. fall direction (azimuth)
13. horizontal distance to stream
14. diameter at edge of bankfull channel
15. recruitment class

Recruited pieces

Additional data will be collected on fallen trees (including broken pieces of trees) that intersect the horizontal or vertical plane of the bankfull channel. To qualify, each tree (or each individual piece) must be at least 4 inches in diameter at the largest end. Data collected on these pieces include:

1. tag number
2. length by channel zone
3. midpoint diameter by channel zone
4. function (sediment storage, step formation, pool formation)

If there is soil disturbance associated with an uprooted tree, additional data will be collected (see “uprooted tree soil disturbance” in the new objectives section).

Understory vegetation

Data on understory vegetation will be collected by re-sampling the existing 1/1000 acre circular understory vegetation plots and collecting data using the same procedures that were used in 2004. There are two transects per patch with 6 plots per transect. The data recorded will include:

1. seedling and sapling tally by species
1. dominant/sub-dominant shrub species
2. mean shrub overstory height
3. percent understory plant cover
4. percent small woody debris cover

Data analysis

A series of response variables for stand conditions, tree mortality and LWD recruitment will be calculated and analyzed to achieve the project objectives. The response variables are described in the next section, followed by a section describing the analyses that will be performed.

Response Variables

1) Stand development and trajectory

A series of metrics will be used to document changes in stand conditions, including: trees per acre, mean breast height diameter, basal area per acre, and quadratic mean diameter. Each of these metrics will be calculated separately for live and dead trees, and for broadleaves and conifers using survey data. These parameters will be reported for each patch (buffer, clear cut, PIP or reference).

Trees per acre. Trees per acre will be calculated by tallying the number of trees and dividing by the acreage surveyed.

Mean breast height diameter. This parameter will be calculated by averaging the mid-point diameters of the trees surveyed.

Basal area per acre. A basal area (BA) will be estimated for each tree using the formula: $BA \text{ (ft}^2\text{)} = 0.005454 \text{ dbh}^2 \text{ (in)}$. This parameter will be calculated by summing the individual basal area of all the trees in the group and dividing by the survey area in acres.

Quadratic mean diameter. Quadratic mean diameter (QMD) in inches will be calculated using the formula:

$$QMD = \sqrt{\frac{BA}{0.005454}}$$

Percent live conifer. Percent live conifer will be calculated two ways, by tree count and by basal area per acre. To calculate percent live conifer trees, the tally of conifers for the area of interest is divided by the total number of live trees. To calculate percent live conifer by basal area, the sum of the basal areas for live conifers is divided by the sum of the basal areas for all live trees.

Dominant tree species. Dominant tree species will be determined by summing basal area by species and identifying the species with the greatest basal area.

2) Understory Vegetation

Four response variables will be estimated for each patch by calculating the mean value of the understory vegetation plots in the patch.

Seedling density per acre. Total live seedling density will be calculated for each plot by patch by dividing the total number of seedlings by the plot area. Separate values will also be calculated for conifer and broadleaf seedlings. Mean patch values will be calculated by averaging the seedling density values for all the plots in the patch.

Sapling density per acre. Total live sapling density will be calculated for each plot by patch by dividing the total number of saplings by the plot area. Separate values will also be calculated for conifer and broadleaf saplings. Mean patch values will be calculated by averaging the sapling density values for all the plots in the patch.

Percent under story cover. A percent understory cover value will be recorded for each plot. Mean patch values will be calculated by averaging the sapling density values for all the plots in the patch.

Percent small woody debris cover. A percent small woody debris cover value will be recorded for each plot. Mean patch values will be calculated by averaging the sapling density values for all the plots in the patch.

3) Tree mortality

Two tree mortality response variables will be calculated, trees per acre per year, and basal area per acre per year. These parameters will be reported for each patch (buffer, clear cut, PIP or reference).

Mortality in trees per acre per year. To calculate mortality rate in trees/acre/year, the number of trees that died between surveys will be counted, divided by area surveyed and divided by the number of years between surveys.

Mortality in basal area per acre per year. To calculate mortality rates in basal area/acre/year, the basal area of trees that died between surveys will be summed, divided by area surveyed and divided by the number of years between surveys.

4) Woody debris recruitment

Fallen trees per acre per year. To calculate fallen trees per acre per year, the total number of trees that fell between surveys will be counted, divided by area surveyed and divided by the number of years between surveys.

LWD pieces recruited per acre per year. To calculate LWD pieces recruited per acre per year, the number of fallen trees pieces that cross the plane of the bankfull channel will be counted, divided by area surveyed and divided by the number of years between surveys.

LWD volume recruited per acre per year. To calculate LWD volume recruited per acre per year, the volume (m³) of fallen trees pieces that cross the plane of the bankfull channel will be counted, divided by area surveyed and divided by the number of years between surveys.

Mean recruited LWD piece volume. This response variable will be calculated by summing the volumes of all LWD pieces recruited during each sampling period and dividing by the total number of pieces.

Percentage of LWD pieces (number and volume) by recruitment class. These response variables will be calculated by sorting recruited LWD pieces by recruitment class and dividing the number (and volume) for each recruitment class by the totals for all pieces.

Analysis

Objective 1 (obtain an unbiased estimate of post-harvest stand conditions, tree mortality and LWD recruitment) will be accomplished by calculating the value for each of the response variables for each patch at each sampling event. Then, the data will be sorted by patch type (buffer, clear-cut, PIP and reference) and descriptive statistics will be reported for each of the four patch types. To provide an estimate of post-harvest conditions at the site scale, the data for each site will be compiled, and sites will be grouped by management group (e.g. sites entirely buffered, sites with buffer and clear cut patches, sites with PIPs and clear cut patches, and sites with buffer, clear cut and PIP patches). Then, for each response variable, a frequency distribution of representing the range of conditions for each type of site (management group) will be prepared and the frequency distributions for each management group will be compared and contrasted.

Objective 2 (evaluate the magnitude and duration of change associated with the prescriptions relative to unharvested reference sites) will be accomplished by calculating the response variables from each sampling event and sorting the data by patch type (buffer, clear-cut, PIP and reference). Then ANOVA, or the non-parametric Kruskal-Wallis test, will be used to determine

if there are significant differences between each treatment patch type and the unharvested reference patches for each response variable.

Objective 3 (identify site and stand attributes that influence response variables). Exploratory regression analysis will be done to evaluate potential relationships between response variables and continuous covariates. Graphical analysis will be done for categorical covariates. These procedures will be used to identify potential relationships of interest. This information can be used to build hypotheses for further testing and to design follow-up studies.

SHADE INDICATORS

Objectives

The uncertainties and assumptions related to riparian shade levels will be addressed by accomplishing the following objectives:

1. Obtain an unbiased estimate of post-harvest shade levels in FFR Type Np riparian buffers and monitor changes over time following application of the prescriptions.
2. Evaluate the duration and magnitude of post-harvest changes in shade at treatment sites relative to untreated reference sites.
3. Identify site and stand attributes that influence shade levels.

Review of 2004 data/methods

Shade data were collected at systematic intervals along the center of the stream channel from a random starting point. The distance between sampling stations was consistent within sites and was scaled so a minimum of 10 samples were obtained for the smallest patch at the sites (except for PIPs). The fixed distances varied between sites (ranging from 29-172 ft), depending on the patch lengths at the site. At each station, four densiometer readings were taken from the center of the bankfull channel (upstream, downstream, right and left bank) and a visual estimate was made of the dominant factor obscuring view-to-sky. A hemispherical canopy photograph was taken at each station. Separate visual estimates were made of the percentage of the stream channel surface obscured by low-growing plants, and of slash/woody debris below the level of the camera and densiometer. Preliminary comparison canopy closure estimates from the densiometer and hemispherical photographs indicate that there is a high correlation between the measurements taken with the two methods (R^2 96.1) and the intercept is near zero and the slope is near one, indicating that the actual values produced from both methods are very similar.

2006 Data Collection Protocols

We propose to collect shade data in 2006 using a similar sampling scheme to 2004 with sampling stations at systematic intervals along the stream channel. Canopy closure will be measured only with a densiometer, in order to streamline processing. Live plant cover data will be collected using the same procedure as in 2004. Woody debris cover data will be collected in conjunction with channel wood loading data (described in section on channel wood loading under new objectives). See Appendix D for a detailed description of the field methods for data collection.

Shade indicator data

Shade indicator data to be collected includes:

1. Percent canopy closure
2. Primary factor obscuring view to sky

3. Percent cover from live under-story plants

Data Analysis

A series of shade indicator response variables will be calculated and analyzed to achieve the project objectives. The response variables are described in the next section, followed by a section describing the analyses that will be performed.

Response Variables

Percent canopy closure. Percent canopy closure will be calculated for each measuring station by averaging the readings (upstream, downstream, left bank, right bank) and multiplying by 1.04.

Percent cover from live under-story plants. The percent cover from live under story plants will be taken from the data sheets.

Analysis

Objective 1 (obtain an unbiased estimate of shade indicators) will be accomplished by calculating the value for each of the response variables for each patch at each sampling event. Then, the data will be sorted by patch type (buffer, clear-cut, PIP and reference) and descriptive statistics will be reported for each of the four patch types. To provide an estimate of post-harvest conditions at the site scale, the data for each site will be compiled, and sites will be grouped by management group (e.g. sites entirely buffered, sites with buffer and clear cut patches, sites with PIPs and clear cut patches, and sites with buffer, clear cut and PIP patches). Then, for each response variable, a frequency distribution of representing the range of conditions for each type of site (management group) will be prepared and the frequency distributions for each management group will be compared and contrasted.

Objective 2 (evaluate the magnitude and duration of change associated with the prescriptions relative to unharvested reference sites) will be accomplished by calculating the response variables from each sampling event and sorting the data by patch type (buffer, clear-cut, PIP and reference). Then ANOVA, or the non-parametric Kruskal-Wallis test, will be used to determine if there are significant differences between each treatment patch type and the unharvested reference patches for each response variable.

Objective 3 (identify site and stand attributes that influence response variables). Exploratory regression analysis will be done to evaluate potential relationships between response variables and continuous covariates. Graphical analysis will be done for categorical covariates. These procedures will be used to identify potential relationships of interest. This information can be used to build hypotheses for further testing and to design follow-up studies.

CHANNEL WOOD LOADING

Objectives

Objectives of the channel wood loading survey are to:

1. Obtain an unbiased estimate of post-harvest channel wood loading in streams adjacent to FFR Type Np riparian buffers following application of the prescriptions over time.
2. Evaluate the duration and magnitude of post-harvest changes in channel wood loading at treatment sites relative to untreated reference sites.

3. Identify site and stand attributes that influence channel wood loading.

2006 Data Collection Protocols

Data will be collected at stations placed at systematic 50 ft intervals along the stream channel using methods described in Appendix E. At each sampling station, collected data will include:

1. Percent total woody debris cover (plan view)
2. Percent suspended woody debris cover (plan view)
3. Percent channel cross-section filled with woody debris
4. Woody debris size
5. Function (sediment storage, step formation, pool formation)
6. Bankfull channel width

Data Analysis

Woody debris cover will be evaluated to determine 1) the percentage of channel bottom area hidden from surface inputs (e.g. light energy, litter fall), 2) the degree to which fluvial conveyance in the bankfull channel may be altered, and the relative contribution to shade by suspended and in-channel wood.

Response Variables

Percent total woody debris cover (plan view). The mean percentage of the bankfull channel area obscured by wood debris; including debris above and within the bank full channel.

Percent suspended woody debris cover (plan view). The mean percentage of the bankfull channel area obscured by woody debris that resides entirely above the plane of the bankfull channel (and is therefore unlikely to interact with flowing water).

Percent channel cross-section filled with woody debris. The mean percentage of bankfull channel cross-sectional area occupied by woody debris.

Analysis

Objective 1: Data from systematically placed sampling stations should provide an unbiased estimate of post-harvest channel wood loading in streams adjacent to FFR Type Np riparian buffers. Each channel wood loading response variable will be sorted by patch type (buffer, clear-cut, PIP and reference) and presented as simple summary statistics (mean, median, minimum, maximum) for treatment types.

Objective 2: Evaluate the duration and magnitude of post-harvest changes in channel wood loading at treatment sites relative to untreated reference sites. Magnitude of response will be determined by calculating the response variables from each sampling event and sorting the data by patch type (buffer, clear-cut, PIP and reference). Then ANOVA, or the non-parametric Kruskal-Wallis test, will be used to determine if there are significant differences between each treatment patch type and the unharvested reference patches for each response variable. Repeat surveys and regression analysis with time as the independent variable will show how response variable change through time.

Objective 3: Site and stand attributes that influence woody debris cover variables will be evaluated post hoc using the all the data collected for this study.

UPROOTED TREE SOIL DISTURBANCE

Objectives

Objectives of the uprooted tree soil disturbance survey are to:

1. Obtain an unbiased estimate of post-harvest soil disturbance from uprooted trees in FFR Type Np riparian buffers following application of the prescriptions over time.
2. Evaluate the duration and magnitude of post-harvest changes in soil disturbance from uprooted trees at treatment sites relative to untreated reference sites.
3. Identify site and stand attributes that influence soil disturbance from uprooted trees.

Review of 2004 data/methods

In the 1st year post-harvest sampling event, an inventory was made of management-related stream bank erosion and soil disturbance features in the equipment limitation zone (ELZ), the area within 30 ft horizontal distance of the channel edge. See Appendix G for a description of the 2004 field methods. The study objective was satisfied with the 1st year post-harvest data and no further survey of management-related soil or stream-bank disturbance features is necessary.

2006 Data Collection Protocols

The 2006 procedures focus on documenting soil disturbance from uprooted trees. Each uprooted tree will be visited, and data will be collected relating to hill slope, root ball and pit volume using methods described in Appendix F (based on Norman et al., 1995).

Measurements from uprooted tree pits will include:

1. depth, width and length of the soil pit
2. distance from stream (slope distance along path that water and sediment would travel)
3. pit location relative to the rootwad
4. hillslope gradient
5. evidence of sediment delivery to the stream channel

Data Analysis

Response Variables

When a tree is uprooted, a root plate composed of root mass and bound soil is displaced. The displacement of roots leaves a pit in the ground. In time, the bound soil is dislodged from the root plate and accumulates on the ground to form a mound. The quantity of soil displaced outside of the pit is a function of several variables including hill slope angle, fall angle, volume and displacement of the rootplate.

Calculating the volume of displaced sediment requires a few simplifying assumptions. First we must assume that trees topple over in a simple hinge fall where the axis of rotation is the pit edge in the direction of fall, and that the tree is uprooted so the root plate comes to rest at approximately right angles to the soil surface (Figure 1). Both these assumptions are supported by previous field studies (Gabet et al., 2003). We shall assume that the shape of the rootplate and pit are described by a half ellipse and that the volume of roots is negligible so that pit volume equals mound volume (Norman et al., 1995). This assumption regarding negligible root volume may not be valid for large conifers like Douglas Fir, though Nicol et al. (2005) found

roots compose only ~7.6% of the rootplate for 40 year old Sitka spruce (*Picea sitchensis*). We shall evaluate this assumption by measuring pit and mound volumes. Finally, we shall assume that sediment falls directly down and lands either in the pit (not mobile) or on the hillside (mobile) (Figure 1). One result of the assumptions provided above, is that trees which fall upslope will be assumed not to deliver sediment because rootplate sediment delivers to the pit.

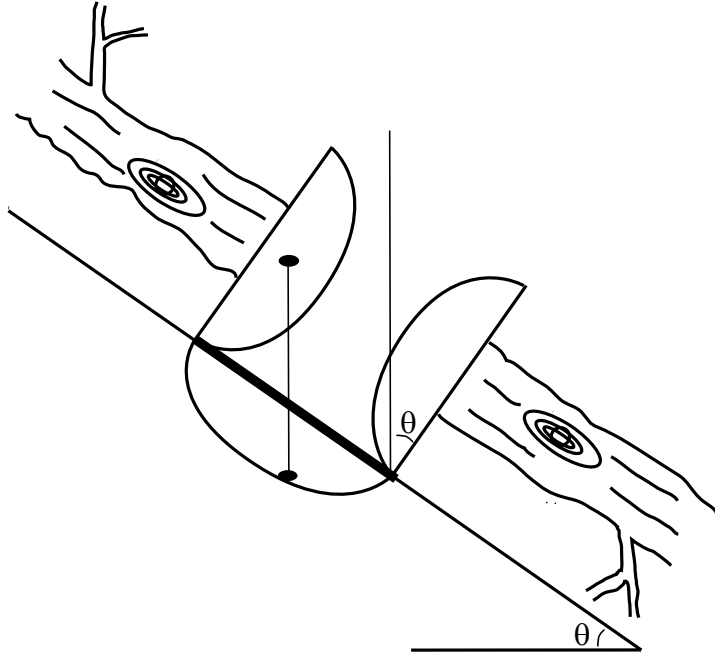


Figure 1: Conceptual diagram showing a tree falling in the upslope and down slope direction. For trees that fall upslope, sediment from the rootplate delivers back to the pit (after Gabet et al., 2003)

Potential sediment delivery volume/acre. The volume of displaced that has the potential to deliver to a stream per unit area will serve as the primary response variable. The total volume of displaced soil/acre will be estimated for each patch by calculating the volume of sediment displaced for all pits associated with uprooted trees and dividing by the area of the RMZ in acres.

Pit and mound volumes will be estimated using a half-ellipsoid equation

$$V = (\pi * W * D * L * \cos(\phi)) / 6 \quad (1)$$

where W, D, and L are the width, depth, and length of the pit and mound, respectively, and ϕ is the deviation from down slope in degrees (only for trees facing down slope, trees facing upslope are assumed to deliver to the pit)

The proportion of the pit volume displaced outside of the pit will be determined using the following equation

$$\left(\frac{\pi \cdot a \cdot b}{2} \right) \left[\frac{1}{2} \left[\frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)} \cdot \frac{2 \cdot b^2 \cdot \sqrt{a} \cdot \tan(\theta)}{b^2 + \tan(\theta)^2 \cdot a} \right] + \int \frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)} \frac{\sqrt{2 \cdot b^2 \cdot a \cdot x - b^2 \cdot x^2}}{a} dx \right] \quad (2)$$

Where a and b are the radius and depth of the pit respectively and θ is the slope angle in degrees. Potential errors associated with assumptions of small root mass will be evaluated by linear regression between pit and mound volumes. In theory, they should be equal for trees that do not deliver sediment.

Total Potential Deliverable Sediment Volume/Acre. Whether displaced sediment delivers to the channel depends on several factors including slope, location of displaced sediment relative to the root pit, and distance to water course. The total volume of potentially deliverable soil/acre will be estimated for each patch by dividing the sum of the volumes of potentially deliverable soil for each uprooted tree in the patch by the area of the RMZ in acres.

The potentially deliverable sediment volume for each mound will be calculated as follows: If the sediment mound is located upslope of the hole and no other delivery mechanism is identified, sediment will be assumed to deliver back the pit (See appendix G). For mounds on the same hill slope contour where no direct delivery mechanism is identified, 1/3 of the displaced sediment will be assumed to deliver back to the pit. For mounds downstream of pits (and the portion of sediment not assumed to deliver to the pit) where no direct delivery mechanism is identified, delivery potential will be estimated using a transport limited hill slope diffusion equation

$$q_s = -V \frac{dz}{dx} \quad (2)$$

in which q_s is delivery potential and V is the volume of displaced sediment not delivering to the pit. In this analysis, sediment flux is assumed to be linearly dependent on local slope.

Analysis

Objective 1: Each response variable will be sorted by patch type (buffer, clear-cut, PIP and reference) and presented as simple summary statistics (mean, median, minimum and maximum) for treatment types.

Objective 2: Magnitude of response will be determined by calculating the response variables from each sampling event and sorting the data by patch type (buffer, clear-cut, PIP and reference). Then ANOVA, or the non-parametric Kruskal-Wallis test, will be used to determine if there are significant differences between each treatment patch type and the unharvested reference patches for each response variable. Change through time will be determined as a regression of sediment delivery against time since harvest.

Objective 3: Site and stand attributes that influence uprooted tree soil disturbance will be evaluated post hoc using the all the data collected for this study.

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APPENDIX A. FIELD METHODS FOR RIPARIAN TREE INVENTORY

This procedure is designed to collect data on live and dead standing trees to characterize the riparian stand characteristics and document tree mortality. Separate procedures are described for fallen trees and LWD recruitment (Appendix B) and understory vegetation (Appendix C).

Layout

Riparian stands and tree mortality are often patchy in nature, so in order to accurately characterize stand conditions and tree mortality rates, a field inventory will be conducted to census all live and dead standing trees in the Type N riparian management zone (RMZ). The RMZ consists of the area within 50 ft horizontal distance of the edge of the bankfull channel on both sides of the stream. In the case of PIP site buffers, the boundary is a circle radiating out 56 ft horizontal distance from the PIP.

Establishing stations at 50 ft intervals along the channel

Establishing stations at 50 ft intervals along the stream channel is the initial step in the layout process. First, carefully determine the valley azimuth (compass bearing) of the channel through the “patch” viewing in an upstream direction. It may be necessary to walk the channel to evaluate whether the orientation of the channel changes in the upper end of the patch if visibility is poor. If the valley azimuth is relatively consistent throughout the patch (within 45 degrees) then a single average bearing is used as the valley azimuth. If there is a major change in the valley orientation in the middle of the patch (>45 degrees) then it will be necessary to do the layout in two segments, with different valley azimuths for both segments.

Layout is done by a two-person crew that proceeds through the reach following the valley azimuth, using laser rangefinder to place stations at 50 ft (horizontal distance) intervals. At each station, wooden stakes are placed just in from the bankfull channel edge on each side of the stream. The top of each stake is painted florescent orange and the station number is written on the side with a permanent marker. The stations in each patch are numbered sequentially, beginning with the number 1. The distance to the last station at the end of the patch is usually less than 50 ft. Place the stakes at the appropriate ending point and record the actual distance from the last station.

At each station, the channel gradient and distance to the next station is recorded. Data on channel wood loading and shade measurements are also typically collected at each station during station layout.

Establishing transects and cell boundaries

Once the markers are in place at 50 ft intervals along the channel, the next step is to establish transects and mark cell boundaries on both sides of the stream channel at each station. Transects extend out to the outer edge of the riparian management zone 50 ft horizontal distance from the edge of the bankfull channel on a bearing perpendicular to the valley azimuth. Transects are established by a two-person team. A person with a laser rangefinder stands beside the stake at the edge of the bankfull channel and the other person with a reflector stands about 50 ft out from the channel. Compasses are used to line up the outer person on the appropriate transect bearing (at a 90 degree angle from the valley azimuth) and the rangefinder is used to determine the point on the transect 50 ft horizontal distance from the bankfull channel stake. If the visibility is poor and it is not possible to see 50 ft it may be necessary to establish the transect in two (or more)

sections. A 6 ft bamboo pole with the top painted florescent orange is used to mark the outer boundary of each transect. Flagging with the transect number is attached to the top of the pole. This procedure is done on each side of the stream.

The following data is collected at each transect as it is being established:

- Total slope. The slope (in degrees) from edge of the bankfull channel to the 50 ft line.
- Landform horizontal distance. The horizontal distance along the transect occupied by each landform type (floodplain, terrace, sideslope, other).
- Side-slope percent slope. The percent slope of the portion of the transect occupied by a “side-slope” landform, if any.

If two or more landforms are present, it will be necessary to get the horizontal distance measurement for each landform using a tape or the laser rangefinder. If a sideslope is present, it will be necessary to get a slope reading from the lower edge of the sideslope landform to either the upper end or the 50 ft line, depending on which is encountered first.

Data Attributes

Many common data attributes are collected for live trees and snags ≥ 4 in DBH; however there are also unique attributes for each (Table A-1).

Table A-1. Data attributes for live trees, dead trees.

Attribute	Live trees	Dead trees
Cell ID number	X	X
Condition	X	X
Species	X	X
Breast height diameter	X	X
Canopy class	X	
Landform	X	X
Damage code	X	
Snag height code		X
Decay class		X
Mortality agent		X
Mortality timing		X
Fallen tree number	*	*

Data Collection Methods

This section describes each data attribute and the methods for collecting the data in more detail. Trees on the edge of the RMZ boundary are considered to be within the RMZ when the majority of the base of the tree lies inside the plot boundary.

Cell Identification Number. Record the unique number identifying the 50 by 50 ft cell where the tree is located. Cells are labeled according to the side of the stream that they occur on (facing downstream) and downstream transect number. For example the first cell on the left bank of the stream at the lower end of the site would be labeled cell L1.

Condition. Condition is recorded as live (L) or dead (D). Dead trees typically have no living leaves or needles. In some cases, they may have green leaves or needles that are in the process of turning yellow. If death appears imminent (in the next year), record as dead.

Species. Identify each tree to species. Field personnel should be familiar with identification of both conifer and hardwood species and carry a field identification manual. The species for each tree should be recorded using the four letter codes in Table A-2. If the species of dead trees cannot be determined, the codes provided for unknown conifer, unknown broadleaf or unknown should be recorded. If other species are found, record species code as the first two letters of genus and first two letters of species.

Table A-2. Species codes for common Pacific Northwest trees.

<i>Common name</i>	<i>Taxonomic name</i>	<i>Code</i>
Conifer species		
Pacific silver fir	Abies amabilis	ABAM
Grand fir	Abies grandis	ABGR
Subalpine fir	Abies lasiocarpa	ABLA
Noble fir	Abies procera	ABPR
Alaskan yellow cedar	Chamaecyparis nootkatensis	CHNO
Western juniper	Juniperus occidentalis	JUOC
Rocky Mountain Juniper	Juniperus scopulorum	JUSC
Supalpine larch	Larix lyallii	LALY
Western larch	Larix occidentalis	LAOC
Whitebark pine	Pinus albicaulis	PIAL
Lodgepole pine	Pinus contorta	PICO
Engelmann Spruce	Picea engelmannii	PIEN
Western white pine	Pinus monticola	PIMO
Ponderosa pine	Pinus ponderosa	PIPO
Sitka spruce	Picea sitchensis	PISI
Douglas-fir	Pseudotsuga menziesii	PSME
Pacific yew	Taxus brevifolia	TABR
Western red cedar	Thuja plicata	THPL
Western hemlock	Tsuga heterophylla	TSHE
Mountain hemlock	Tsuga mertensiana	TSME
Unknown conifer	-	UC
Broadleaf species		
Bigleaf maple	Acer macrophyllum	ACMA
Red alder	Alnus rubra	ALRU
Pacific madrone	Arbutus menziesii	ARME
Water birch	Betula occidentalis	BEOC
Paper birch	Betula papyrifera	BEPA
Western flowering dogwood	Cornus nuttallii	CONU
Red-osier dogwood	Cornus stolonifera	COST
Black hawthorne	Crataegus douglasii	CRDO
Oregon ash	Fraxinus latifolia	FRLA
Pacific crab apple	Malus fusca	MAFU
Quaking aspen	Populus tremuloides	POTR
Black cottonwood	Populus trichocarpa	POTR2
Bitter cherry	Prunus emarginata	PREM
Choke cherry	Prunus virginiana	PRVI
Oregon white oak	Quercus garryana	QUGA
Cascara	Rhamnus purshiana	RHPU
Willow species	Salix spp	SALX
Unknown broadleaf	-	UB
Unknown	-	UK

Breast height diameter. Tree diameter at breast height (DBH) is recorded in 4 inch increments (Table A-3).

Table A-3. Diameter categories.

Code (midpoint dia)	Diameter Range
6	≥ 4 - < 8 in
10	≥ 8 - < 12 in
14	≥ 12 - < 16 in
18	≥ 16 - < 20 in
22	≥ 20 - < 24 in
26	≥ 24 - < 28 in
30	≥ 28 - < 32 in
34	≥ 32 - < 36 in
Etc.	

If the observer is confident in visually estimating the size category, then it can be recorded without making a measurement. If the tree appears to be near the break between diameter categories and the observer is not confident in assigning the tree to a category, then the diameter should be measured in order to assign the tree to a size category, using the methods in WDNR (1996). The measurement is taken 4.5 ft (1.37 m) from the ground on the upslope side of the tree. This distance should be

measured along the bole if the tree is leaning. Diameter tapes should be extended around the tree perpendicular to the bole. When the tree has an abnormality (such as a limb, bulge, or buttresses) at breast height, the diameter should be measured above it to obtain the diameter the tree would have had without the abnormality. Crooked, pistol butt shaped tree bases should be measured at 4.5 ft above the crook. Diameter tapes should be rounded out over scars or cat faces. If a tree forks or is grown together at or above breast height, measure the diameter for the single tree below the abnormality caused by the fork. If a tree forks below breast height, measure each stem as an individual tree 3.5 ft (1.07 m) above the fork. If there are stems growing out of a stump, measure the diameter of the stems 4.5 ft. from the top of the stump.

Canopy Class. Record the canopy class (dominant, co-dominant, intermediate, suppressed) for each live tree using the codes provided (bolded letter). Canopy class refers to the height of the individual tree in relation to the rest of the canopy. The following descriptions are adapted from Avery and Burkhardt (1994).

- **Dominant (D)** - $\geq 25\%$ of the tree crown is above the forest canopy. Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than average trees in the stand, with crowns well developed but possibly somewhat crowded on the side.
- **Co-dominant (C)** – tree crown is within the main forest canopy. Trees with crowns forming the general level of the crown cover and receiving full light from above, but comparatively little from the sides; usually with small crowns considerably crowded on the sides.
- **Intermediate (I)** - $\geq 25\%$ of the lower tree crown is below the main forest canopy. Trees shorter than those in the two preceding classes, but with crowns either below or extending into the crown cover formed by co-dominant and dominant trees, receiving little direct light from above and none from the sides; usually with small crowns considerably crowded on the sides.
- **Suppressed (S)** – entire tree crown is below the main forest canopy. Also sometimes referred to as overtopped. Trees with crowns entirely below the general level of the crown cover, receiving no direct light either from above or from the sides.

See the diagram (Figure A-1) for a visual representation of canopy classes.

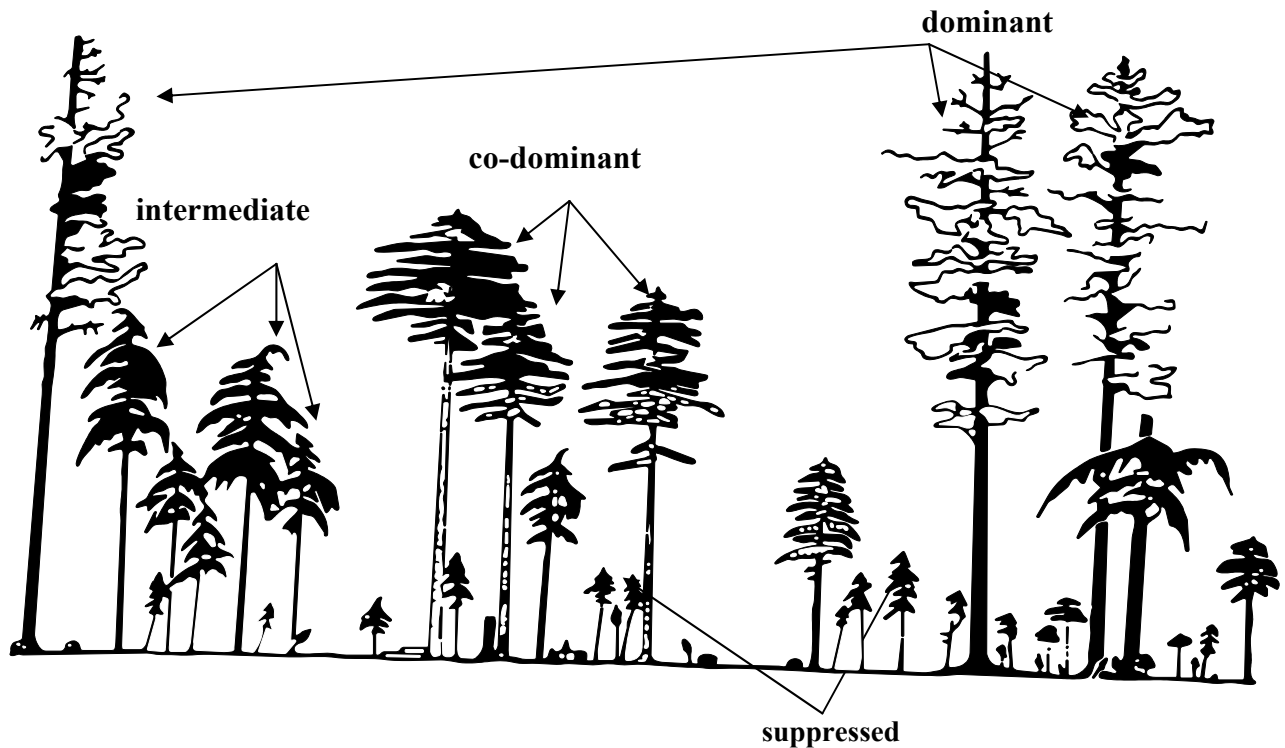


Figure A-1. Description of canopy class types (Adopted from: Stewart 1986).

Landform. Each tree is assigned to one of four landforms: floodplain, terrace, side-slope or planar landform. Table A-4 provides a description of the landforms and guidance for identifying landforms in a medium size stream. However the elevations of the floodplain and terraces are scaled to the size of the stream, increasing for large rivers and decreasing for small streams. In the field the landform should be assessed and recorded using slope, terrain features and estimated elevation above the channel.

Table A-4. Description of landform features.

Landform Feature	Description
Floodplain (F)	An area adjacent to stream inundated by water during overbank floods (< 3.3 ft elevation above channel for small river)
Terrace (T)	A relatively flat terrace landform (including face) adjacent to the stream but not inundated by overbank floods
Side slope (S)	An area with a convergent slope towards the stream that does not consist of alluvial depositional features
Other (O)	An area not draining directly into the stream reach of interest (for example: planar slopes, a glacial plain, a slope draining into an adjacent stream valley)

Live Tree Damage Code. Damage code for each live tree should be recorded using the codes provided in Table A-5.

Table A-5. Live tree damage codes.

Code	Damage	Descriptions
BT	Broken top	Top broken off of living tree
DC	Dead crown	Live tree with over 50% of crown dead
DF	Discolored foliage	Live tree with over 50% of foliage discolored (red, brown, yellow, orange)
FT	Forked top	Live tree with multiple tops (used for conifers only)
LS	Large scar	Live tree with damage penetrating bark on over 33 % of circumference
RC	Rot/decay	Live tree with fungi or other evidence of rot or decay

Snag Height Code. Assign a code to each standing dead tree to indicate its height (Table A-6).

Table A-6. Snag height codes.

Code	Description
1	≥ 100 ft
2	≥ 50 - <100 ft
3	≥ 20 - < 50 ft
4	<20

Decay Class. Decay class code for each standing dead tree should be recorded using the codes provided in Table A-7 (from Hennon et al., 2002). Decay class should be determined by applying a weight of evidence approach using the criteria.

Table A-7. Decay class codes for snags and fallen trees.

Snag/log class	Description
1	Foliage (dead leaves and needles) present
2	Twigs present
3	Secondary branches present
4	Primary branches present
5	No branches remaining (nubs may be present)

Mortality Agent. Record the mortality agent (cause of death) for standing dead trees using the codes in Table A-8.

Table A-8. Codes for tree mortality agents.

Mortality agent (code)
Fire (F)
Wind (W)
Insect (I)
Suppression (S)
Desiccation (D)
Physical Damage (P)
Unknown (U) - describe in notes

Mortality Timing. Record the timing of mortality for each dead tree when it is observed to distinguish trees that died before harvest from those that died during/after harvest. Categories include **pre-harvest**, **post-harvest**.

Fallen Tree Number. If there is a qualifying fallen tree piece that broke off of a standing tree, record the tag number so the standing tree and the fallen piece can be associated in the data base.

References

Avery, T.E. and H.E. Burkhardt. 1983. Forest Measurements. Third Edition. McGraw-Hill, Inc. New York, New York. 331 p.

Hennon, P.E., M.H. McClellan, and P. Palkovic. 2002. Comparing deterioration and ecosystem function of decay-resistant and decay-susceptible species of dead trees. USDA Forest Service Gen. Tech. Rpt. PSW-GTR-181.

Stewart, G.H. 1986. Forest development in canopy openings in old-growth *Pseudotsuga* forests of the western Cascade Range, Oregon. Canadian Journal of Forest Research. 16(3): 558-568.

Washington Department of Natural Resources. 1996. Field procedures for forest resource inventory system. Washington Department of Natural Resources. Olympia.

APPENDIX B. FIELD METHODS FOR FALLEN TREES AND WOODY DEBRIS RECRUITMENT

This procedure is designed to collect post-harvest data on fallen trees and woody debris recruitment. Fallen tree data are collected only on trees that are knocked down or toppled over as a result of the harvest operation as well as trees that have blown down or fall over during the post-harvest period. Fallen trees include either entire trees that fall after being uprooted (if the roots no longer support the weight of the tree) or pieces of trees where their tops or branches have broken off. In either case, the large end of the tree (or piece) must be ≥ 4 inches in diameter to qualify as a fallen tree. In cases where the top portion of a tree is broken off while the stem remains standing, the standing portion is treated as a standing tree and the broken portion is treated as a fallen tree (if large enough to qualify). Standing tree data is collected for the standing portion and fallen tree data is collected for the broken portion. Data on a fallen tree are collected only once, the first time it is observed. Fallen trees are tagged so newly fallen trees can be distinguished on subsequent surveys.

Additional data on woody debris recruitment are collected on qualifying fallen tree pieces that cross the plane of the bankfull channel.

Layout

Tree fall and woody debris recruitment are often patchy. To accurately determine tree fall rates and woody debris recruitment, a field inventory will census all fallen trees that originate from (were rooted in) the riparian management zone (RMZ). For Type Np streams, the RMZ is within 50 ft horizontal distance of the edge of the bankfull channel on both sides of the stream. PIP buffers are circular, with a radius of 56 ft horizontal distance from the PIP. Trees on the edge of the RMZ boundary are considered to be within the RMZ when the majority of the base of the tree lies inside the plot boundary. Fallen trees originating outside the RMZ will not be measured.

Data Attributes

The attributes collected for all fallen trees are shown in Table B-1 along with the data recording protocols. Additional attributes for the portions of the fallen trees that recruit within the plane of the bankfull channel are shown in Table B-2. Note that if there is more than one piece per tree that recruits to the channel each piece should be recorded separately.

Table B-1. Attributes for fallen trees.

Parameter	Recording protocol
Tree number	Number from tag
Cell identification no	Two character code based on side of stream (L or R, and upstream transect no.)
Condition	Single letter code (D or L)
Species	Four letter code, Table A-2
Diameter breast height	Decimal inches
Type	Two letter code, see Table B-3
Number of pieces	Integer
Number of pieces recruited	Integer
Process	Single letter code, Table 12
Decay class	Single number code, visually determined, Table 6

Landform	Two letter code (Table B-6)
Total length	Decimal feet
Fall direction	Azimuth direction (from base)
Distance from stream	Horizontal distance in decimal feet
Diameter at channel edge	Decimal inches
Recruitment class	(Bankfull channel, spanning, suspended, floodplain, upland)

Table B-2. Additional attributes for woody debris pieces that recruit to bankfull channel.

Parameter	Recording protocol
Tree number	Record the tree number
Piece number	Record the piece number
Length by zone	Length of piece in ft to the nearest inch for each zone
Mid-point diameter by zone	Record mid-point diameter in inches, to the nearest tenth inch for each zone
Function	Note if piece contributes to: sediment storage, step formation or pool formation

Data Collection Methods

Fallen Tree Data

Tree number. Tag each fallen tree piece with a numbered metal tag (painted florescent orange) and record the tree tag number. Fallen trees are given a tag during the first survey of a site.

Cell identification number. Record the unique number identifying the cell where the tree was originally rooted. For broken pieces, this would be the cell where the “parent” standing tree stem is located.

Condition. Determine whether the fallen tree is either (**D**) dead or (**L**) alive by looking for signs of new shoot growth. Dead trees typically have no living leaves or needles. In some cases, they may have green leaves or needles that are in the process of turning yellow. If death appears imminent (in the next year), record as dead.

Species. Record the species code (Table A-2, Appendix A).

Breast height diameter. For an uprooted fallen tree, measure the stem diameter 4.5 feet above the root collar (upper portion of the root wad), i.e. at the same location as a dbh measurement would have been taken if the tree were still standing. For ‘broken’ fallen trees, the dbh measurement of the associated standing tree snag is used. If this is not possible, take the measurement at the base (largest end) of the largest piece. If the downed piece is broken, split or splintered, estimate the diameter at the largest end.

Type. Record the type of fallen tree as in Table B-3.

Table B-3. Fallen tree types.

Description	Code
Uprooted with rootwad attached	U
Broken portion of bole	B

Number of pieces. Record the number of pieces the tree broke into when it fell. If the tree is not uprooted, do not count the standing portion of the tree as a fallen piece.

Process. Note the process that caused the tree to fall down or the piece to break off, using the codes in Table B-4.

Table B-4. Codes for processes causing trees to fall.

Felling process (code)
Fire (F)
Wind (W)
Erosion (E)
Cut (C)
Yarding (Y) (knocked over, cable whipped, toppled toehold tree etc.)
Other (O), describe in notes
Unknown (U)

Decay class. Decay class code for each standing dead tree should be recorded using the codes provided in the first column of Table B-5. Decay class should be determined by applying a weight of evidence approach using the criteria in Table B-5.

Table B-5. Decay class codes for snags and fallen trees.

Snag/log class	Description
1	Foliage (dead leaves and needles) present
2	Twigs present
3	Secondary branches present
4	Primary branches present
5	No branches remaining (nubs may be present)

Landform. Each tree is assigned to one of four landforms: floodplain, terrace, side-slope or other. Table B-6 provides a description and guidance for identifying landforms.

Table B-6. Description of landform features.

Landform Feature	Description
Floodplain (F)	An area adjacent to stream inundated by water during overbank floods (< 3.3 ft elevation above channel for small river)
Terrace (T)	A relatively flat terrace landform (including face) adjacent to the stream but not inundated by overbank floods
Side slope (S)	An area with a convergent slope towards the stream that does not consist of alluvial depositional features
Other (O)	An area not draining directly into the stream reach of interest (for example: planar slopes; glacial plain; valley draining to adjacent channel)

Total length. Record the length of the fallen tree to the point on main stem or largest fork where it is no longer 4 inches in diameter. If broken into pieces, sum the piece lengths to the 4 inch diameter cut-off point.

Fall direction. Record the azimuth of tree fall from where the tree was rooted to the end of the tree. If the fallen tree has broken into pieces, take the azimuth from where the tree was rooted to where the largest piece crosses the bank full channel. If no pieces have recruited to the channel, aim to the center point of the largest piece to estimate the fall direction.

Distance from stream. Using a laser hypsometer, measure the horizontal distance from bankfull channel edge to location where the fallen tree was originally rooted.

Diameter at edge of bankfull channel. Record the diameter where the fallen tree (or largest piece) crosses the plane of the bankfull channel.

Number of pieces recruited. Record the number of broken pieces that have recruited into the stream, i.e. have broken the plane of the bankfull channel.

Recruitment class. Recruitment class describes the relationship of the overall piece to the bankfull channel. Table B-7 lists the recruitment classes in a hierarchical order based on potential function, from the channel to the uplands. A single piece often meets the criteria for more than one recruitment class along its length, however only the “highest” class that applies to a piece should be recorded. For example, if even a small portion of a piece intrudes into the bankfull channel, it should be recorded as a bankfull recruitment class even if other, larger portions of the same piece are spanning, suspended, floodplain or upland. Figure B-1 visually presents the recruitment classes.

Table B-7. Description of recruitment class categories for down wood.

Recruitment class	Description
Bankfull (BF)	Some part of the tree enters the bankfull channel
Spanning (SP)	Tree is supported above bankfull channel by banks on both sides of stream
Suspended (SU)	The tree is suspended above the bankfull channel
Floodplain (FP)	Tree touches floodplain but does not intersect plane of bankfull channel
Upland (UP)	Tree does not intersect the bankfull channel or touch the floodplain

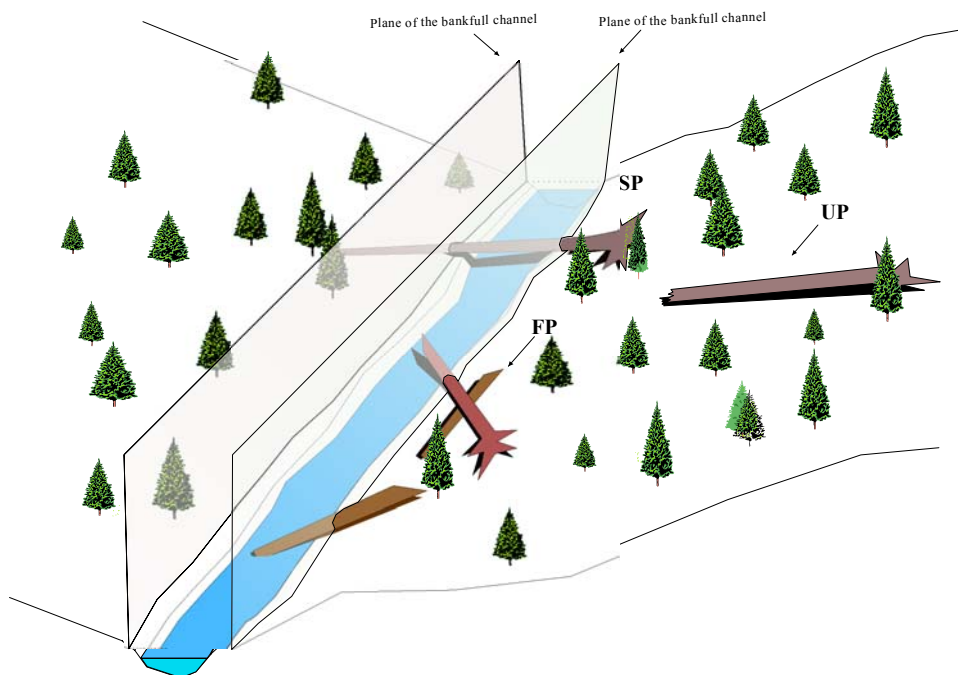


Figure B-1. Visual display of recruitment classes. See table B-5 for codes.

Additional Data for Pieces Recruited to the Channel

Length by zone. Large woody debris pieces fall into 3 zones defined by the bankfull channel edges (Figure B-2). Zone 1&2 includes the bankfull and wetted channels. Zone 3 is directly above the channel as defined by the vertical planes of the bankfull channel edges. Zone 4 is outside the bankfull channel. For each piece, record the length (in ft) within each zone. Figure B-3 displays how to measure the lengths within the zones.

Midpoint diameter by zone. Measure the diameter at the midpoint of each zone (in inches).

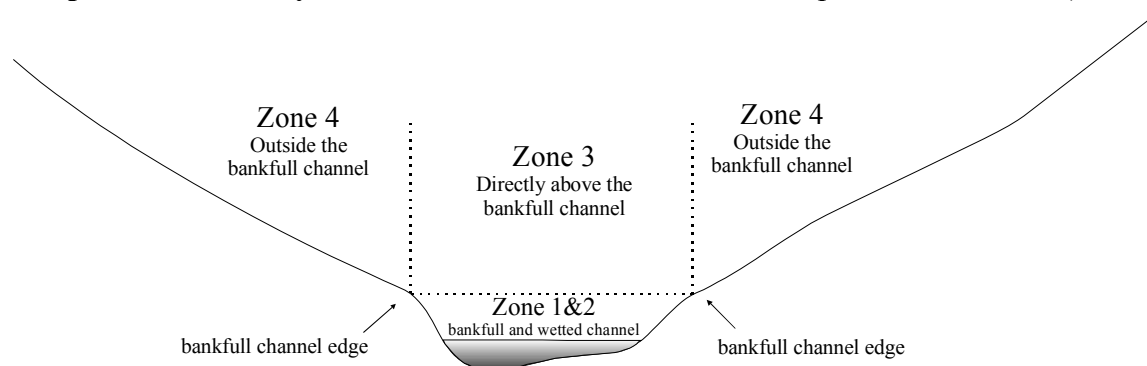


Figure B-2. Criteria for channel zone identification (adapted from Schuett-Hames et al., 1999).

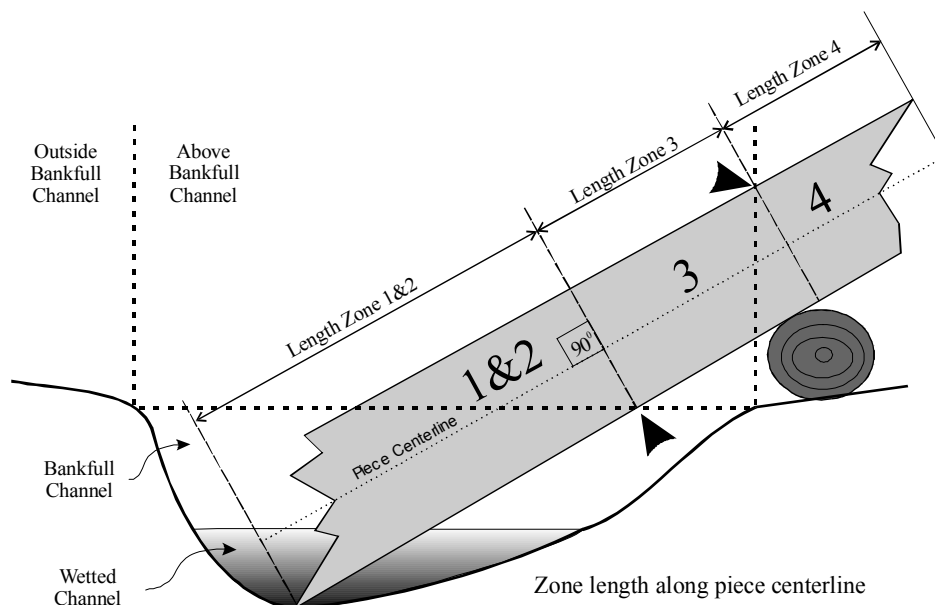


Figure B-3. Measuring Zone 1&2, 3, and 4 lengths (adapted from Schuett-Hames et al., 1999).

Function. Note if the piece is contributing to sediment storage, step formation or pool formation.

References

Schuett-Hames, D.E., A.E. Pleus, J. Ward, M. Fox and J. Light. 1999. TFW Monitoring Program method manual for the large woody debris survey. TFW-AM9-99-004. Forest Practices Division. Washington Department of Natural Resources, Olympia, WA.

APPENDIX C. FIELD METHODS FOR UNDERSTORY VEGETATION

This procedure is designed to collect data describing conditions related to tree regeneration, including tree seedling and saplings, understory vegetation cover and woody debris cover.

Layout

A series of small, circular plots are arrayed on two transects placed at randomly selected locations along the stream in each patch. There are six plots at each transect, three on each side of the stream. The plots are centered on the transect at distances of 10, 25 and 40 ft (horizontal) from the edge of the bankfull channel. Plots are labeled 'Veg1', 'Veg2', and 'Veg3' in sequence moving outward from the channel. A pin flag with the label is placed in the center of each plot.

Each plot is 3.72 horizontal feet in radius on a flat surface, or 1/1000 of an acre. Use a tape held level to determine the radius (plot boundary) from the plot center. If this is not possible, use a handheld clinometer to determine the slope of each regeneration plot. Once the correct slope radius for a regeneration plot has been determined (Table C-1), measure it out in the upslope and downslope direction, holding the tape parallel to the slope (not level). The radii to the sides (along the contour of the slope) remain 3.72 ft., meaning the regeneration plots become increasingly oval shaped with increasing slope.

Table C-1. Adjustments for plots radius and layout based on slope.

degree slope	slope radius (ft - percent)	slope radius (ft - absolute units)	10' slope distance (ft - percent)	10' slope distance (ft - absolute units)
0	3.72	3' 9	10.00	10' 0
1 - 5	3.73	3' 9	10.02	10' 0
6 - 10	3.76	3' 9	10.10	10' 1
11 - 15	3.82	3' 10	10.27	10' 3
16 - 20	3.91	3' 11	10.52	10' 6
21 - 24	4.04	4' 0	10.83	10' 10
25 - 28	4.16	4' 2	11.18	11' 2
29 - 32	4.32	4' 4	11.61	11' 7
33 - 36	4.52	4' 6	12.14	12' 2
37 - 39	4.72	4' 9	12.69	12' 8
40 - 41	4.89	4' 11	13.15	13' 2
42 - 43	5.05	5' 1	13.56	13' 7
44 - 45	5.22	5' 3	14.02	14' 0

Data Attributes

The following attributes are collected in this survey:

1. Seedling tally by species
2. Sapling tally by species
3. Dominant/sub-dominant understory species
4. Percent understory vegetation cover
5. Percent small woody debris cover
6. Mean shrub overstory height

Data Collection Methods

Seedling and sapling tallies. Seedlings are defined as tree species with heights ≥ 6 in (15 cm) and dbh < 1 in (1.5 cm); and saplings from dbh ≥ 1 in (2.5cm) to 4 in (10cm). Tally tree seedlings and saplings by species in each plot.

Dominant/sub-dominant understory species. Record the dominant and sub-dominant understory species in each plot using the four letter codes in Table C-2.

Table C-2. Species codes for common Pacific Northwest shrubs.

Species code	Taxonomic name	Common name	Category
ACCI	<i>Acer circinatum</i>	vine maple	vine maple
ADBI	<i>Adenocaulon bicolor</i>	pathfinder	wildflower
ADPE	<i>Adiantum pedatum</i>	maiden hair fern	other fern
AMAL	<i>Amelanchier alnifolia</i>	Saskatoon serviceberry	other shrub
ATFIFE	<i>Athyrium filix-femina</i>	lady fern	other fern
BENE	<i>Berberis nervosa</i>	Oregon grape	Oregon grape
BLSP	<i>Blechnum spicant</i>	deer fern	other fern
BUDDL	<i>Buddleia</i> spp.	butterfly bush	wildflower
CIAR	<i>Cirsium arvense</i>	Canada thistle	wildflower
CLPY	<i>Cladothamnus pyroliflorus</i>	copperbush	other shrub
COCO	<i>Corylus cornuta</i>	beaked hazelnut	other shrub
CONU	<i>Cornus nuttallii</i>	Pacific dogwood	other tree
CRDO	<i>Crataegus douglasii</i>	black hawthorn	other shrub
CYSC	<i>Cytisus scoparius</i>	Scotch broom	other shrub
DIFO	<i>Dicentra formosa</i>	Pacific bleeding heart	wildflower
DIPU	<i>Digitalis purpurea</i>	common foxglove	wildflower
EPAN	<i>Epilobium angustifolium</i>	fireweed	wildflower
EQAR	<i>Equisetum arvense</i>	common horsetail	other fern
GAOV	<i>Gaultheria ovatifolia</i>	western tea-berry	other shrub
GASH	<i>Gaultheria shallon</i>	salal	salal
GATR	<i>Galium triflorum</i>	sweet scented bedstraw	wildflower
HODI	<i>Holodiscus discolor</i>	oceanspray	other shrub
JUEF	<i>Juncus effusus</i>	common rush	grass/sedge/rush
LOCI	<i>Lonicera ciliosa</i>	western trumpet honeysuckle	other shrub
LOIN	<i>Lonicera involucrata</i>	black twinberry	other shrub
LYAM	<i>Lysichiton americanum</i>	Skunk cabbage	wildflower
MADI	<i>Maianthemum dilatatum</i>	false lily-of-the-valley	wildflower
MARE	<i>Mahonia repens</i>	Oregon-grape	Oregon grape
MEFE	<i>Menziesia ferruginea</i>	fool's huckleberry	other shrub
OECE	<i>Oemleria cerasiformis</i>	Indian plum	other shrub
OPHO	<i>Oplopanax horridum</i>	Devil's club	other shrub
OSSP	<i>Osmorhiza</i> sp.	carrot	wildflower
OXOR	<i>Oxalis oregensis</i>	oxalis	wildflower
PHMA	<i>Physocarpus capitatus</i>	Pacific ninebark	other shrub
POGL	<i>Polypodium glycyrrhiza</i>	licorice fern	other fern
POMU	<i>Polystichum munitum</i>	sword fern	swordfern
PREM	<i>Prunus emerginata</i>	bitter cherry	other tree
PRVI	<i>Prunus virginiana</i>	chokecherry	other tree

PTAQ	<i>Pteridium aquilinum</i>	bracken fern	other fern
RHAL	<i>Rhododendron albiflorum</i>	white flowered rhododendron	other shrub
RHMA	<i>Rhododendron macrophyllum</i>	Pacific rhododendron	other shrub
RIBES	<i>Ribes</i> sp.	currant	other shrub
RIBR	<i>Ribes bracteatum</i>	stink currant	other shrub
RIVI	<i>Ribes viscosissimum</i>	sticky currant	other shrub
ROGY	<i>Rosa gymnocarpa</i>	baldhip rose	other shrub
RONA	<i>Rosa nutkana</i>	Nootka rose	other shrub
RUDI	<i>Rubus discolor</i>	Himalaya blackberry	other shrub
RULA	<i>Rubus lasiococcus</i>	dwarf bramble	other shrub
RUPA	<i>Rubus parviflorus</i>	thimbleberry	other shrub
RUSP	<i>Rubus spectabilis</i>	salmonberry	salmonberry
RUUR	<i>Rubus ursinus</i>	trailing blackberry	other shrub
SACE	<i>Sambucus cerulea</i>	blue elderberry	other shrub
SARA	<i>Sambucus racemosa</i>	red elderberry	other shrub
SATO	<i>Saxifraga tolmiei</i>	Tolmie's saxifrage	wildflower
SAXI	<i>Saxifraga</i> sp.	unknown saxifrage	wildflower
SEJA	<i>Senecio jacobaea</i>	tansy ragwort	wildflower
SESY	<i>Senecio sylvaticus</i>	wood groundsel	wildflower
SOSI	<i>Sorbus sitchensis</i>	Sitka mountain-ash	other shrub
SPDO	<i>Spiraea douglasii</i>	hardhack	other shrub
SYMP	<i>Symphoricarpos albus</i>	snowberry	other shrub
TEGR	<i>Tellima grandiflora</i>	fringecup	wildflower
TITR	<i>Tiarella trifoliata</i>	foamflower	wildflower
VACOVA	<i>Vaccinium ovatum</i>	evergreen huckleberry	huckleberry
VACOVL	<i>Vaccinium ovalifolium</i>	ovalleaf huckleberry	huckleberry
VAHE	<i>Vancouveria hexandra</i>	inside-out flower	wildflower
VAPA	<i>Vaccinium parvifolium</i>	red huckleberry	huckleberry
UKFR	--	unknown fern	other fern
UKGR	--	unknown grass	grass/sedge/rush
UKSH	--	unknown shrub	other shrub
UKWF	--	unknown wildflower	wildflower

Percent understory vegetation cover. Estimate the overall percent shrub/sapling/seedling cover in each regeneration plot as viewed from above.

Percent woody debris cover. Estimate the percent cover of small woody debris in each plot.

Mean shrub overstory height. Estimate mean height of the shrub overstory. Shrubs include plants which typically have woody and often multiple stems, and for the purposes of this study, ferns (see Table C-2 for a list of common shrubs and ferns). Consult Pojar and MacKinnon, (1994) for shrub identification.

References

Pojar, J and A. MacKinnon. 1994. Plants of the Pacific Northwest Coast. B.C. Ministry of Forests and Lone Pine Publishing. Vancouver, B.C.

APPENDIX D. FIELD METHODS FOR SHADE INDICATORS

Layout

The following steps are involved in establishing sampling stations for collecting shade indicator data.

1. Determine the distance (interval) between stations for systematic sampling
2. Select a random starting point distance from the edge of the site to locate the first station
3. Continue along the stream laying out additional stations at systematic intervals

Layout procedure for “simple” sites. If the site is a simple (only one patch type throughout its entire length), then a minimum of 10 sampling stations are needed. To determine the distance between stations for systematic layout, take the reach length in feet and divide by 10, then round to the nearest 5 feet. This is the interval (distance) between stations in feet (i). Next, randomly select a number between 1 and i . This is the distance along the stream from the edge of the unit to the first station. Establish the first station at this location, flag it and collect data. Then, continue along the stream, systematically establishing the additional stations at each interval (i) throughout the entire length of the site.

Layout procedure for “complex” treatment sites. If the treatment site is complex (both a clear cut and a buffered patch) then a minimum of 10 sampling stations are needed for each patch. However, the distance between stations (the interval i), should be the same for both patches. To determine the distance between stations, take the length in feet of the shorter of the two patches and divide by 10, then round to the nearest 5 feet. This is the interval (distance) between stations in feet (i), which is applied to both patches. Next, randomly select a number between 1 and i . This is the distance along the stream from the edge of the unit to the first station. Establish the first station at this location, flag it and collect data. Then, continue along the stream, systematically establishing the additional stations at each interval (i) throughout the entire length of the site.

Procedures sites with PIP buffers. If the site has a PIP buffer (i.e., has both a clear cut and a PIP buffer, and possibly a buffered section as well) then a minimum of 10 sampling stations are needed for each clear cut or buffer patch and a minimum of two stations are needed for the PIP buffer. The distance between stations (the interval i), should be the same for the patches and the PIP. To determine the distance between stations, take the length in feet of the shorter of the two patches and divide by 10, then round to the nearest 5 feet. If the number is less than 50 ft, this is the interval (distance) between stations in feet (i), which is applied to each patch and the PIP. However, if the number is greater than 50 ft, then use 50 ft as the distance between stations (i) to ensure that there are at least two stations in the PIP. Next, randomly select a number between 1 and i . This is the distance along the stream from the edge of the unit to the first station.

Establishing Sampling Stations. At each interval, establish a sampling station. Mark each station with flagging marked with the sequential station number and distance from the starting point. Note this information on the form, along with the patch type.

Data Attributes

Shade indicator data to be collected includes:

1. Percent canopy closure
2. Primary factor obscuring view to sky
3. Percent cover from live under-story plants

Data Collection Methods

Canopy Closure

Take densiometer measurements at each station using the methods described in Pleus and Schuett-Hames (1998). Four measurements are taken from the center of the bankfull channel, one each facing upstream, towards the left bank, downstream and towards the right bank. Record the number of dots covered by vegetation in each direction on the data form.

Finally, indicate on the field form whether the majority of the canopy cover is provided by trees (T), shrubs (S), or other (O). If other, describe in the field form.

Live Plant Cover

The purpose of this measurement is to estimate the percentage of the bankfull channel obscured by live plants that are below the level of the densiometer readings or hemispherical photos and would not be documented by the canopy closure measurements. The area covered by the estimate includes the entire width of the bankfull channel extending 2 ft above and below the sampling station, for a total of 4 feet of stream length. Using the percent cover diagrams on the field form as a guide, estimate the percentage of this area obscured by live plants below waist height when viewed from above. Record the percentage on the field form and indicate the dominant species using the four letter code if possible.

References

Pleus, A.E. and D.E. Schuett-Hames. 1998. TFW Monitoring Program method manual for the reference point survey. TFW-AM9-98-002. Forest Practices Division. Washington Department of Natural Resources, Olympia, WA.

APPENDIX E. FIELD METHODS FOR CHANNEL WOOD LOADING

The purpose of this measurement is to visually estimate the percentage of channel surface shaded from light and other inputs, and percentage of bank full channel area obscured by woody debris.

Layout

These measurements are taken at 50 ft intervals along the stream using the layout procedures described in Appendix A for the standing tree survey.

Data Attributes

Five measurements are taken at each sampling station (Table F-1).

Table F-1. Data collected to channel burial.

Measurements	Description	Format
Percent total woody debris cover (plan view)	Percentage of the bank full channel obscured by woody debris (viewed from overhead)	%
Percent suspended woody debris cover (plan view)	Percentage of bank full channel obscured by portions of woody debris pieces suspended entirely above the channel (not interacting with flow)	%
Percent channel cross-section filled with woody debris	The proportion of bank full channel conveyance blocked by debris.	%
Woody debris size	Indicate the dominant size of the woody debris (S= ≤ 4 in dia; L = ≥ 4 in dia; M= mixed sizes).	Categorical S – M - L
Function	Indicate if the debris contributing to sediment storage, step formation or pool formation	Categorical S or P
Bank full width	Bankfull channel width measured	Decimal ft

Data Collection Methods

At each station, the area surveyed for plan view woody debris cover includes the entire width of the bank full channel extending 2 ft above and below the sampling station, for a total of 4 feet of stream length. The two plan view measurements down from above. Percent total woody debris cover is the percentage of bankfull channel area covered by all woody debris. Percent suspended woody debris cover is the percentage of the bankfull channel area covered only by portions of woody debris pieces that are suspended above the channel and do not interact with flow at bankfull discharges. The percent of bank full channel cross-section filled with woody debris is estimated along a transect each station, taking a cross-sectional view of the bank full channel. It is a proxy measurement for the proportion of bank full volume filled with woody debris.

Percent total woody debris cover (plan view). Using the percent cover diagrams on the field form as a guide, estimate the percentage of bankfull channel area obscured by any woody debris when viewed from above.

Percent suspended woody debris cover (plan view). Same as the above measurement but only considers portions of woody debris pieces entirely suspended above the bank full channel. (Percent suspended woody debris cover must be \leq the percent of total woody debris cover).

Percentage of bank full channel cross-section filled with woody debris. If the channel is visible, estimate the percentage of bankfull cross-section filled with debris on a transect line across the bankfull channel at the station. If the channel is totally buried (i.e. no part of the bankfull channel can be seen through the debris), indicate this in the field notes.

Woody debris size. Large woody debris (L) is defined as 4 inches or more in diameter. Small woody debris (S) is defined as wood, branches or twigs < 4 inches in diameter. If neither large nor small woody debris is comprises more than 60% of the total, indicate that the debris is mixed (M).

Function. Note if the woody debris in the sampling area is contributing to sediment storage, step formation, or pool formation.

Bankfull width: Take one bank full width measurement at each station using the methods described in Pleus and Schuett-Hames (1998). Take the width measurement perpendicular to the channel direction at the station. If the alignment of the stakes on each edge of the bankfull channel is not perpendicular to the channel at the station, do not measure from stake to stake but take the measurement perpendicular to the channel at a point between the stakes.

References

Pleus, A.E. and D.E. Schuett-Hames. 1998. TFW Monitoring Program method manual for the reference point survey. TFW-AM9-98-002. Forest Practices Division. Washington Department of Natural Resources, Olympia, WA.

APPENDIX F. FIELD METHODS FOR UPROOTED TREE SOIL DISTURBANCE

Layout

Follow the layout in Appendix A and identify all uprooted trees that are within 50 horizontal feet of the bank full channel.

Data Attributes

The data attributes to be measured are listed in Table G-1.

Table G-1. Data collected to calculate potential sediment delivery.

Measurements	Description	Format
Pit depth (D_p)	Measured from the deepest part of the pit and perpendicularly intersecting the hill slope plane	Decimal feet
Pit width (W_p)	Measured in the down slope direction	Decimal feet
Pit length (L_p)	Measured parallel to the local slope contour	Decimal feet
Slope (\square)	Slope angle	Degrees
Direction of tree fall	Direction of tree fall relative to slope in hour hand system with 12 o'clock directly upslope and 6 o'clock directly down slope.	Number
Distance to stream	Slope distance to stream in the down slope direction	Decimal feet
Sediment delivery	Note if there is evidence of sediment delivery to the stream	Yes, No

Pit depth. Pits are depressions left in the ground after a tree has been uprooted. Pit depth is the distance from the deepest part of the pit to the hill slope plane (see Figure G-1). The only exception to the “deepest part of the pit” rule is when the deepest part of the pit would clearly result in significant over- or under-estimation of pit volume.

Pit width. Width refers to the diameter of the pit in the down slope direction (see Figure G-1).

Pit length. Length refers to the diameter of the pit in the direction of hill slope contour (see Figure G-1).

Slope. The degree slope measurement should reflect the slope of the area on which the pit is located. If possible, this measurement is taken between two points on undisturbed ground immediately upslope and downslope of the pit. In some cases, it may be necessary to move to the side of the pit in order to take a reading.

Direction of tree fall. Recorded in hour-hand denotation with 12 o'clock in the upslope direction and 6 o'clock in the down slope direction (e.g. 6 for a tree that fell directly down slope from the pit).

Distance to stream. Slope distance in decimal ft to the stream along the path that water and sediment will travel to reach the stream. This is best determined with a measuring tape. If a rangefinder is used, the distance is **not** measured as horizontal distance, but rather slope distance.

Sediment delivery. Indicate whether there is evidence of sediment reaching the stream from the pit or mound (yes = Y, no = N).

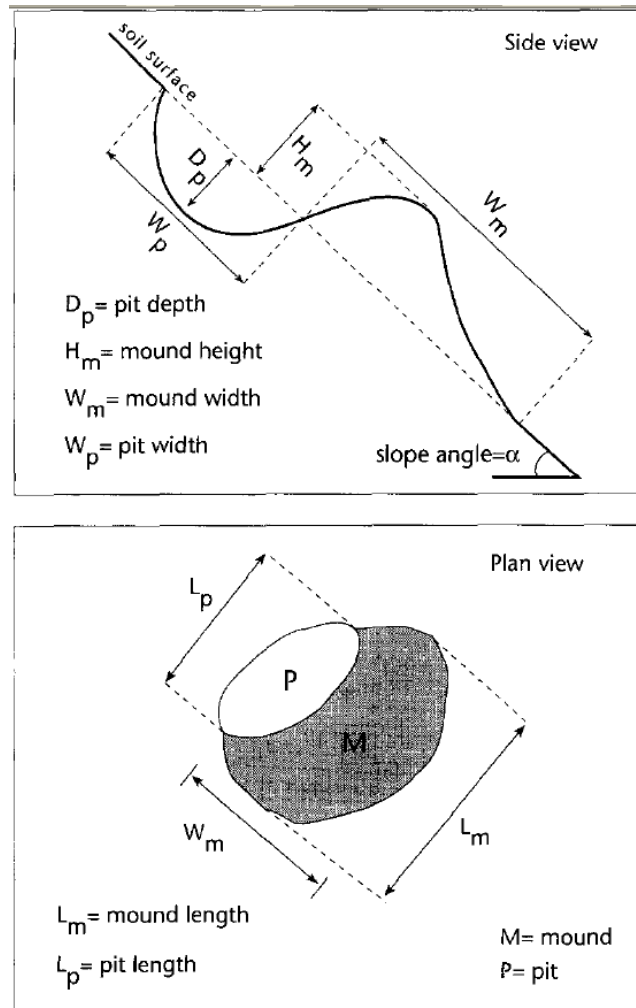


Figure G-1. Uprooted tree pit measurements (after Norman et al. 1995)

The following are the equations developed to determine the percentage of the root plate that would deliver to the hill slope vs. the pit. As shown by Figure G-1 in the text, the volume that delivers to the hill slope assuming the tree is pointed directly down slope is a function of hill slope angle and the shape of the ellipse. We can determine portion of the ellipse that would deliver to the hill slope by intersecting a gravitational line with the ellipse and determining the areas under the curve (shaded in Figure G-2).

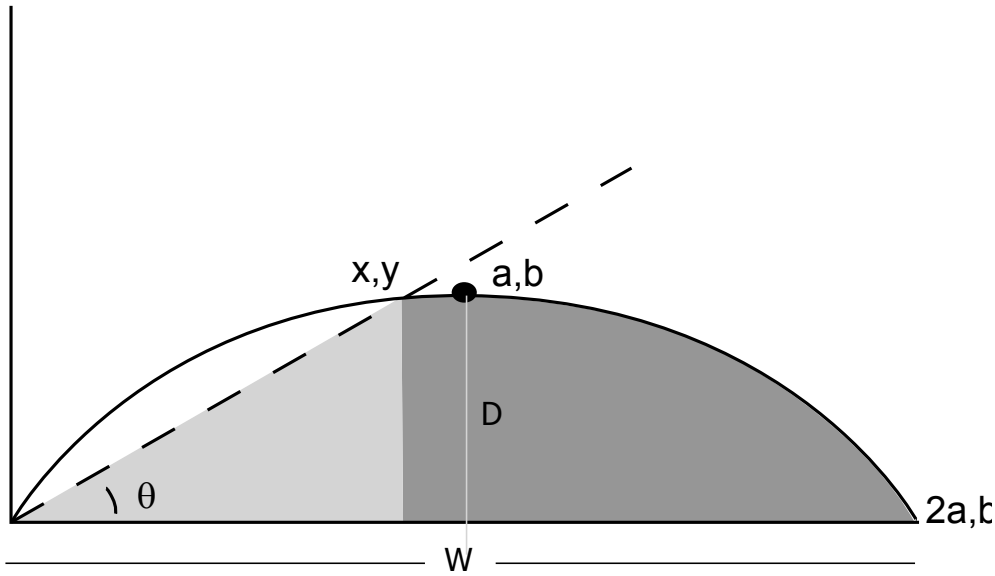


Figure G-2. Gravitational line intersection an ellipse.

Given	Equation of a line	$y = x \cdot \tan(\theta)$	(1)
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Equation for an ellipse	$\frac{(x-a)^2}{a^2} + \frac{y^2}{b^2} = 1$	(2)
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Rearranging the ellipse formula	$b^2 \cdot x^2 - 2 \cdot b^2 \cdot x \cdot a + y^2 \cdot a^2 = 0$	(3)
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Substituting in the line eq.	$b^2 \cdot x^2 - 2 \cdot b^2 \cdot x \cdot a + [x \cdot \tan(\theta)]^2 \cdot a = 0$	(4)
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Solving for x gives two solutions	$x = 0 \quad x = \frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)}$	(5)
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The intersection of the line therefore occurs at (0,0) and	$\left[\frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)}, \frac{2 \cdot b^2 \cdot \sqrt{a} \cdot \tan(\theta)}{(b^2 + \tan(\theta)^2 \cdot a)} \right]$	(6)
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The area of the triangle is therefore:	$A_1 = \frac{1}{2} \left[\frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)} \cdot \frac{2 \cdot b^2 \cdot \sqrt{a} \cdot \tan(\theta)}{b^2 + \tan(\theta)^2 \cdot a} \right]$	(7)
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Taking equation 3 and solving for y	$y = \frac{\sqrt{2 \cdot b^2 \cdot a \cdot x - b^2 \cdot x^2}}{a}$	(8)
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The area under the curve from x to the end of the ellipse ($2 \cdot a$) is

$$A_2 = \int_{\frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)}}^{2a} \frac{\sqrt{2 \cdot b^2 \cdot a \cdot x - b^2 \cdot x^2}}{a} dx \quad (9)$$

Area of a half ellipse

$$\text{Area} = \frac{\pi \cdot a \cdot b}{2} \quad (10)$$

Proportion of area displaced downslope

$$\frac{A_1 + A_2}{\text{Area}} \quad (11)$$

Example Problem:

$$\text{Width}_{\text{pit}} := 3\text{m}$$

$$\text{Length}_{\text{pit}} := 5\text{m}$$

$$\text{Depth}_{\text{pit}} := 2\text{m}$$

$$\text{Slope} := 30\text{-deg}$$

$$\text{Down}_{\text{deviation}} := 0\text{-deg}$$

$$a := \frac{\text{Width}_{\text{pit}}}{2\text{m}}$$

$$b := \frac{\text{Depth}_{\text{pit}}}{\text{m}}$$

$$c := \frac{\text{Length}_{\text{pit}}}{2\text{m}}$$

$$\theta := \text{Slope}$$

$$\phi := \text{Down}_{\text{deviation}}$$

$$\text{Area}_{\text{ellipse}} := \frac{\pi \cdot \text{Width}_{\text{pit}} \cdot \text{Depth}_{\text{pit}}}{4}$$

$$\text{Area}_{\text{ellipse}} = 4.712\text{m}^2$$

$$\text{Area}_{\text{down}} := \left[\frac{1}{2} \left[\frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)} \cdot \frac{2 \cdot b^2 \cdot \sqrt{a} \cdot \tan(\theta)}{b^2 + \tan(\theta)^2 \cdot a} \right] + \int_{\frac{2 \cdot b^2 \cdot a}{(b^2 + \tan(\theta)^2 \cdot a)}}^{2a} \frac{\sqrt{2 \cdot b^2 \cdot a \cdot x - b^2 \cdot x^2}}{a} dx \right] \cdot \text{m}^2$$

$$\text{Area}_{\text{down}} = 1.962\text{m}^2$$

$$\% \text{down} := \frac{\text{Area}_{\text{down}}}{\text{Area}_{\text{ellipse}}}$$

$$\% \text{down} = 0.416$$

$$\text{Volume} := \left[\left(\frac{2}{3} \cdot \pi \cdot a \cdot b \cdot c \right) \cdot \text{m}^3 \cdot \% \text{down} \right] \cdot \cos(\phi)$$

$$\text{Volume} = 6.541\text{m}^3$$

References

Norman, S.A., Schaetzl, R.J. and Small, T.W., 1995. Effects of slope angle on mass movement by tree uprooting. *Geomorphology*, 14(1): 19.

APPENDIX G. FIELD METHODS FOR SOIL DISTURBANCE AND STREAM BANK INTEGRITY (2004 ONLY)

Layout

Collect data on stream bank and soil disturbances by walking along both sides of the stream and visually inspecting the equipment limitation zone (area within 30 horizontal feet of the stream). Identify all stream-bank disturbance or soil disturbance features that meet all of the following criteria: 1) are within 30 horizontal feet of the bankfull channel, 2) were caused by harvest or yarding activity, and 3) have a surface area of $> / = 10$ sq ft. Measure and record data only on the areas of a disturbance feature that fall within the 30 foot equipment limitation zone and disregard any part of the disturbance which falls beyond the equipment limitation zone. Disturbances caused by wind-throw that has occurred after the treatment harvest should be included in this survey.

Data Attributes

Table D-1 displays the data attributes and recording protocols for each disturbance feature.

Table D-1. Data recorded for stream bank and equipment limitation zone disturbance features.

Disturbance feature	Recording protocols
Feature number	Sequential number
Patch ID	Text and number
Bank	Two letter code: 'rb' (right bank); 'lb' (left bank)
Distance from bottom of patch	Horizontal feet, to the nearest tenth
Total length	Horizontal feet, to the nearest tenth
Mean width	Horizontal feet, to the nearest tenth
Length of disturbed stream bank	Horizontal feet, to the nearest tenth
Distance to bankfull edge	Horizontal feet, to the nearest tenth
Slope	Percent slope
Sediment delivery?	Single letter code, Y(es) or N(o)
Obstructions	Two letter code, refer to Table 16
Cause of disturbance	Two letter code, refer to Table 17
Photo #	Number
Disturbance feature notes	Text

Data Collection Methods

Feature number. Assign a number to each disturbance feature as encountered, starting at 1 and proceeding sequentially.

Patch ID. Record the patch type and patch number the disturbance feature is located in.

Bank. Record whether the feature is located on the 'rb' (right bank) or 'lb' (left bank).

Distance from bottom of patch. Record the horizontal distance along the stream to the downstream boundary of the patch.

Total length. Measure the horizontal distance of the longest axis of the feature in feet.

Mean width. Measure the horizontal distance width of the feature in feet, perpendicular to the longest axis at one or more locations. The number of measurements required to adequately estimate the width will depend on the shape of the feature.

Length of disturbed stream bank. Measure in feet the horizontal length of disturbed stream bank if the disturbance feature connects directly to the stream bank. Record the length as '0' if the disturbance does not connect with the stream bank.

Distance to bankfull edge. Measure and record in feet the horizontal distance from the nearest edge or point of the disturbance feature to the stream. Record a distance of '0' for disturbance features that connect directly to the stream bank.

Slope. Measure and record the percent slope from the edge of the bankfull channel to the nearest edge or point of the disturbance feature. Leave blank if the disturbance is directly connected with the stream bank.

Sediment delivery? Record Y(es) or N(o) whether there is evidence that sediment from the disturbance has been delivered into the stream.

Obstructions. Record the types of obstructions between the disturbance feature and the stream according to the codes in Table D-2. Obstructions can include logs, plants or topographical features that could block delivery of sediment from the disturbance to the stream. If more than one obstruction is present, record the obstruction you think would be most effective at blocking sediment delivery into the stream. Record information about other obstructions in the notes.

Table D-2. Obstructions that could prevent soil from a disturbance from entering the stream.

Material	Description	Code
No obstructions	No visible obstructions between disturbance feature and stream	XX
Live vegetation	Shrubs and other live plants on the stream bank	LV
Woody debris	Pieces of wood \geq 3.9 inch diameter and \geq 6.6 ft. length	WD
Organic debris	Pieces of wood < 3.9 inch diameter or < 6.6 ft. length	OD
Inorganic particles	Boulders, rocks, gravel piles, etc.	IP
Other	Describe in notes	OT

Cause of disturbance. Use the codes in Table 17 to assign a cause to the disturbance feature. Treat a disturbance feature caused by both felling and subsequent log-dragging as a single yarding feature. For features where it is not clear whether the disturbance was caused by felling or log-dragging, list yarding as the cause.